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AN EOCENE MEGAFOSSIL FLORA FROM NELLY CREEK, SOUTH AUSTRALIA

by D. C. CHRISTOPHEL*, L. J. SCRIVEN* & D. R. GREENWOOD**

Summary

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Clay from the Eyre Formation in Nelly Creek in far north South Australia contains the first Middle Eocene mummified leaf flora reported from the interior of Australia. The 269 leaves collected are placed in 16 parataxa, with one angiosperm parataxon of unknown affinity providing 64% of the flora. Eleven of the 16 parataxa can be assigned to extant families which include Proteaceae, Myrtaceae, Araucariaceae, Podocarpaceae, Casuarinaceae and Lauraceae. *Myrtaciphyllum cremeaensis* sp. nov. is formally described.

Comparison with Middle Eocene megafossil floras suggests that the Nelly Creek flora is taxonomically distinct and physiognomically more sclerophyllous than the other south-eastern Australian floras. However, sampling programs in extant rainforests and other Eocene deposits suggest that the number of parataxa (16) recorded at Nelly Creek from this first collection will likely increase markedly with further collections.

Comparison with the silcrete floras of northern South Australia, in particular the Poole Creek flora, demonstrates that while some taxa, including a possible Proteaceae infructescence, are common to both deposits, the majority of both floras do not correspond.

KEY WORDS: Fossil, Eocene, Nelly Creek, Silcrete, Myrtaceae.

Introduction

The Middle Eocene flora of Australia is well known from megafossil localities in south eastern Australia. These include the Anglesea flora (e.g. Christophel 1984; Christophel & Lys 1986; Christophel *et al.* 1987, Hill 1980; Rowett & Christophel 1990), the Golden Grove flora (Barrett & Christophel 1990; Christophel & Greenwood 1989), the Maslin Bay flora (Lange 1970; Christophel & Blackburn 1978; Blackburn 1981) and the Nerriga flora (Hill 1978, 1983). These occur near the coast, with the first three considered to be lowland and the last (Nerriga) to be upland (Fig. 1). All of these floras have been interpreted as representing tropical to sub-tropical (or very warm temperate at the minimal) rainforest communities (Christophel 1989; Christophel & Greenwood 1989) and all contain well preserved, compressed or mummified leaves, allowing maximum potential for interpretation.

A second source of data on Early Tertiary floras in southern Australia comes from the extensive impression and cast floras of interior southern and central Australia, collectively known as the silcrete floras. While known for a relatively long time (Chapman 1937), these floras have not played a major role in interpreting Tertiary vegetation because of the lack of stratigraphic control. More recently, Ambrose *et al.* (1979) suggested an Eocene age for some of these silcretes, including those described by Lange (1978) containing leptospermoid Myrtaceae fruits. Recent work by Greenwood *et al.* (1990[1]) described a flora from the Poole Creek area of South Australia and placed the age as Middle Eocene based on lithostratigraphic correlations. Fossil pollen has not been preserved in these silcretes and hence palynology could not be used to confirm their age.

The discovery in 1986 by R. Callen of fossiliferous clays in northern South Australia which contained well preserved, compressed and mummified leaves and which was interpreted as Middle Eocene (Alley 1989[2]) was important for several reasons. Firstly, it greatly extends the geographic range of well-preserved, Middle Eocene megafossil floras. Secondly, it provides biostratigraphically datable evidence for a truly inland, lowland flora of that age, and finally, it provides the possibility of better chronological control over the interpretation of the numerous silcrete floras of the interior (Ambrose *et al.* 1979; Greenwood *et al.* 1990). The aims of this report are therefore to provide a preliminary description of the megafossil flora of Nelly Creek, to formally describe a new species of Myrtaceae from this deposit, and to compare the parataxa from Nelly Creek with the known silcrete elements.

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[1] GREENWOOD, D. R., CALLEN, R. A. & ALLEY, N. F. (1990) The correlation and depositional environment of Tertiary strata based on macrofloras in the southern Lake Eyre Basin, South Australia. S.A. Department of Mines and Energy Report 90/15, 1-57, Plates 1-7.

[2] Alley, N. F. (1989) Preliminary Palynological dating of macrofloras from Eyre Formation, Nelly Creek, Lake Eyre Basin. Dept. of Mines and Energy of South Australia Rept Bk No. 89/46.

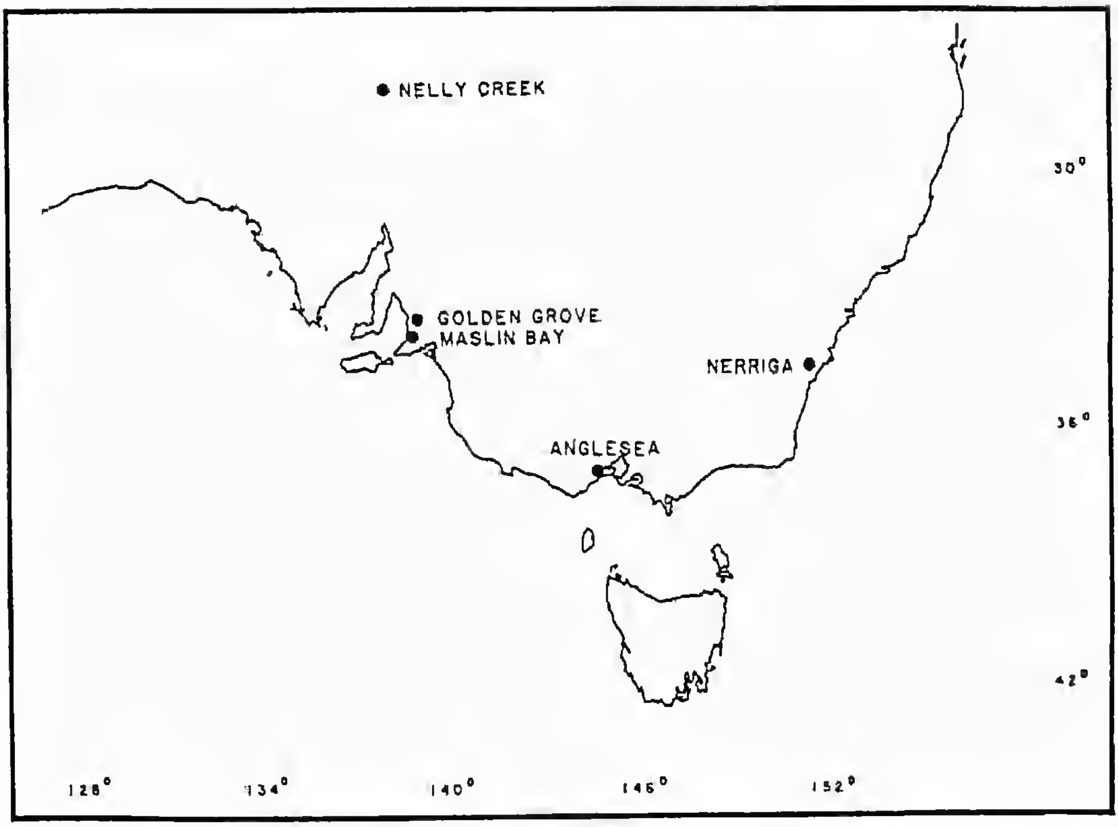


Fig. 1. Map of southeastern Australia showing the location of Nelly Creek and other Middle Eocene plant megafossil localities.

Materials and Methods

The Nelly Creek flora is contained in the Eyre Formation located at 29°19′S, 137°18′E, approximately 1 km south of the southern shore of Lake Eyre South (Fig. 1). The deposit consists of sands, silts and grey, carbonaceous clays forming a portion of the bed of Nelly Creek. Overlying strata consist of partially silicified sediments, disaggregated sands, and a salt-pan crust. The deposit is restricted to the stream bed and is only accessible when little or no water is found in Nelly Creek. The fragility of the material, as well as the terrain and general inaccessibility have severely limited the amount of material collected to date. The extent of the fossiliferous clay horizon outside the stream channel is unknown, although fossiliferous clays have been intersected in a number of bore holes in the region (N. Alley pers. comm.). The width of the deposit within the stream bed is less than 3 metres, and its thickness less than 1 metre.

The high water table and the high salt content of the ground water result in freshly excavated, moist blocks drying quickly with a salt crust. Most southern Australian clays containing mummified leaves can be disaggregated by immersion in approximate 7% w/v H_2O_2 which has been heated. Salt in the Nelly Creek matrix interferes with disaggregation, and maceration is only successful if the blocks have been either presoaked in distilled water to remove some of the salt, or if a detergent such as Quaternary O is added to the maceration mixture. Approximately 40% of the leaves obtained from a given macerate are translucent (Fig. 2, A–C) while other specimens are black/opaque and much more brittle. Leaf remains obtained in this fashion are contained in complete cuticular envelopes and treatment with hot H_2O_2 (e.g. Scriven & Christophel 1990) followed by staining in crystal violet yields clean, easily photographed cuticle specimens. Cuticles from this deposit prepare easily and are in a better state of preservation than those of any other Eocene deposit previously examined by the authors. Two frequent causes of cuticular abrasion or fragility are alkalinity of the matrix (or ground water) and presence of excessive fungal activity during, or prior to, fossilization. Based on the excellent preservation, both of these factors were either absent or minimal during the burial and subsequent fossilization of the Nelly Creek leaves. All specimens figured in this paper

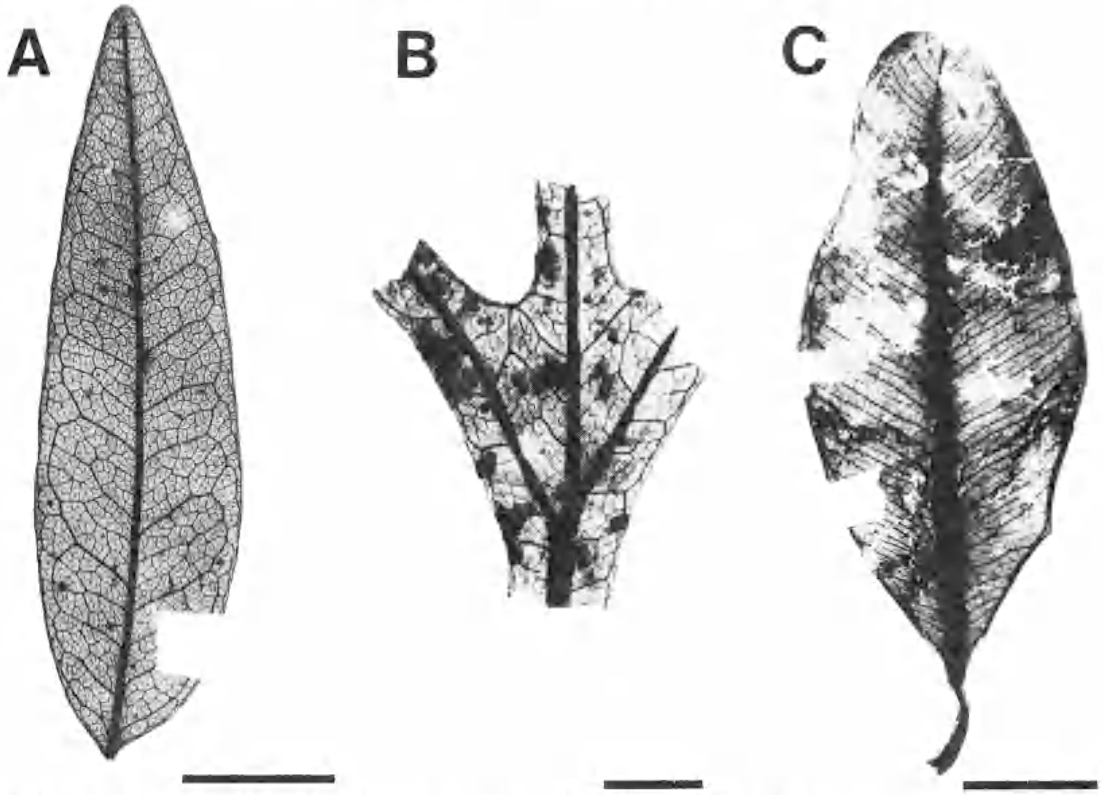


Fig. 2. Selected leaves from Nelly Creek deposit. A = specimen NC1000 and is an example of Parataxon 1 (affinities unknown); B = specimen NC1012 and is an example of Parataxon 2 (Proteaceae); C = NC1017 and is an example of Parataxon 3 (Myrtaceae) – it is the holotype of *Myrtaciphyllum eremeaensis*; Scale bars = 1 cm.

have been mounted in phenol glycerin jelly and are housed permanently in the Palaeobotany Collection, Botany Department, Adelaide University.

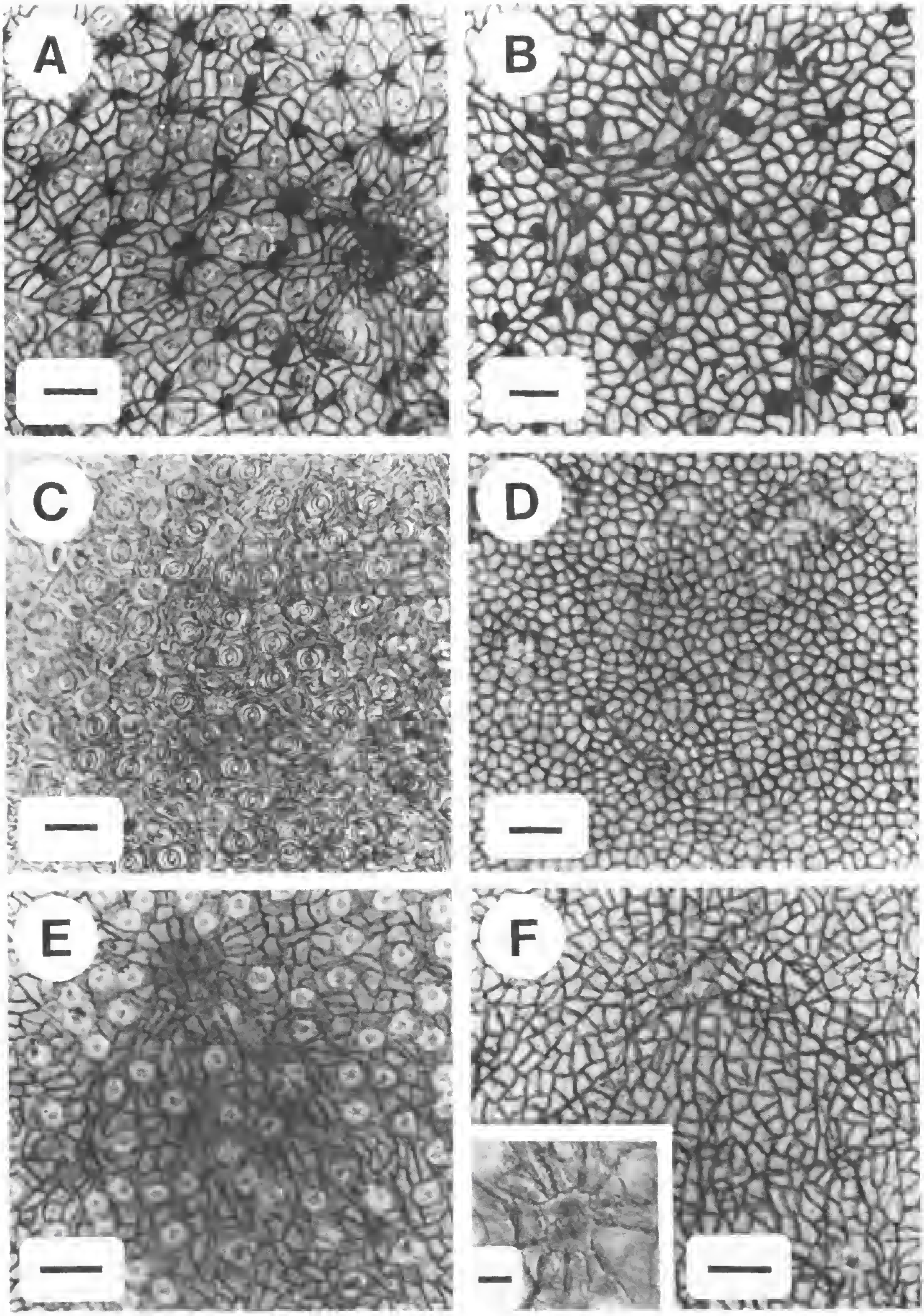
The Middle Eocene age is based on the well preserved pollen flora contained within the sediments (Alley 1989[2]). As he reported, the Nelly Creek palynoflora correlates with the Lower *Nothofagidites asperus* Zone of Stover & Partridge (1973) and with the *Proteacidites pachypolus* Zone of Harris (1971), and the Nelly Creek flora is correlative with the floras at Maslin Bay and Golden Grove.

Floristics of the locality

Collections made by N. F. Alley in 1986 and by the first and third authors and others in 1988 have been macerated to yield a collection of 220 broadleafed specimens (each representing 50% or more of a leaf) and numerous small specimens including *Gymnostoma* (Casuarinaceae) twigs, Podocarpaceae twigs, and various unidentified fruits and seeds. Broken leaves and detrital sievings from the macerations have also been kept for dispersed cuticle analysis.

TABLE 1. *Leaf megafossil composition of the first blocks macerated from the Nelly Creek clay lens.*

Parataxon Number	Number of Specimens (% of the Flora)		Affinities
1	172	(64)	UNKNOWN
2	16	(6)	PROTEACEAE
3	15	(5.5)	*MYRTACIPHYLLUM*
4	3	(1)	*AGATHIS*
5	1	(0.5)	LAURACEAE
6	1	(0.5)	*BRACHYCHITON*
7	2	(1)	PROTEACEAE
8	3	(1)	MONOCOT
9	3	(1)	PROTEACEAE
10	1	(0.5)	UNKNOWN
11	1	(0.5)	UNKNOWN
12	1	(0.5)	PROTEACEAE
13	1	(0.5)	UNKNOWN
14	25	(9)	PODOCARPACEAE
15	14	(5.5)	*GYMNOSTOMA* SP A
16	10	(3)	*GYMNOSTOMA* SP B
TOTAL	269	(100)	


A
B
C
D
E
F

The 220 specimens recovered could be divided into 13 parataxa based on both macromorphological features and cuticular structures (Table 1). The analysis of the material clearly showed a dominance of the sample by one parataxon (Parataxon 1, Fig. 2A, 3A–B). The leaves of Parataxon 1 are generally microphylls with a few being classed as notophylls (*sensu* Webb 1959). All are entire margined and most display apices with a general ovate to elliptical shape. Following the descriptive terminology of Hickey (1979), primary venation of Parataxon 1 is pinnate with brochidodromous secondary venation and reticulate tertiary veins. Generally, five orders of vein branching are present.

The cuticle of Parataxon 1 is hypostomatic with numerous stomates displaying either two or three subsidiary cells. Both abaxial and adaxial surfaces are densely covered with simple, collared trichomes (Fig. 3A–B). This collared appearance could represent torn tissue from glandular apices on the trichomes, but the general excellent preservation of the cuticles and the large number of specimens sampled does not support that hypothesis.

It has not been possible to determine the affinities of this dominant parataxon. Several large Australian rainforest families can be easily recognised by their cuticular structure. Such identifying features have been discussed for the Lauraceae (Hill 1986), Proteaceae (Lange 1970) and Myrtaceae (Christophel & Lys 1986). Therefore, it is possible to eliminate these families in the identification process. However, several other large families, including the Fabaceae, Euphorbiaceae, Sapindaceae and Oleaceae all have taxa with leaves approximating the venation pattern and general macromorphology of the Nelly Creek dominant. It is also possible that the fossil could represent a family or lower level taxon which is now extinct, and thus no reasonable match could be forthcoming.

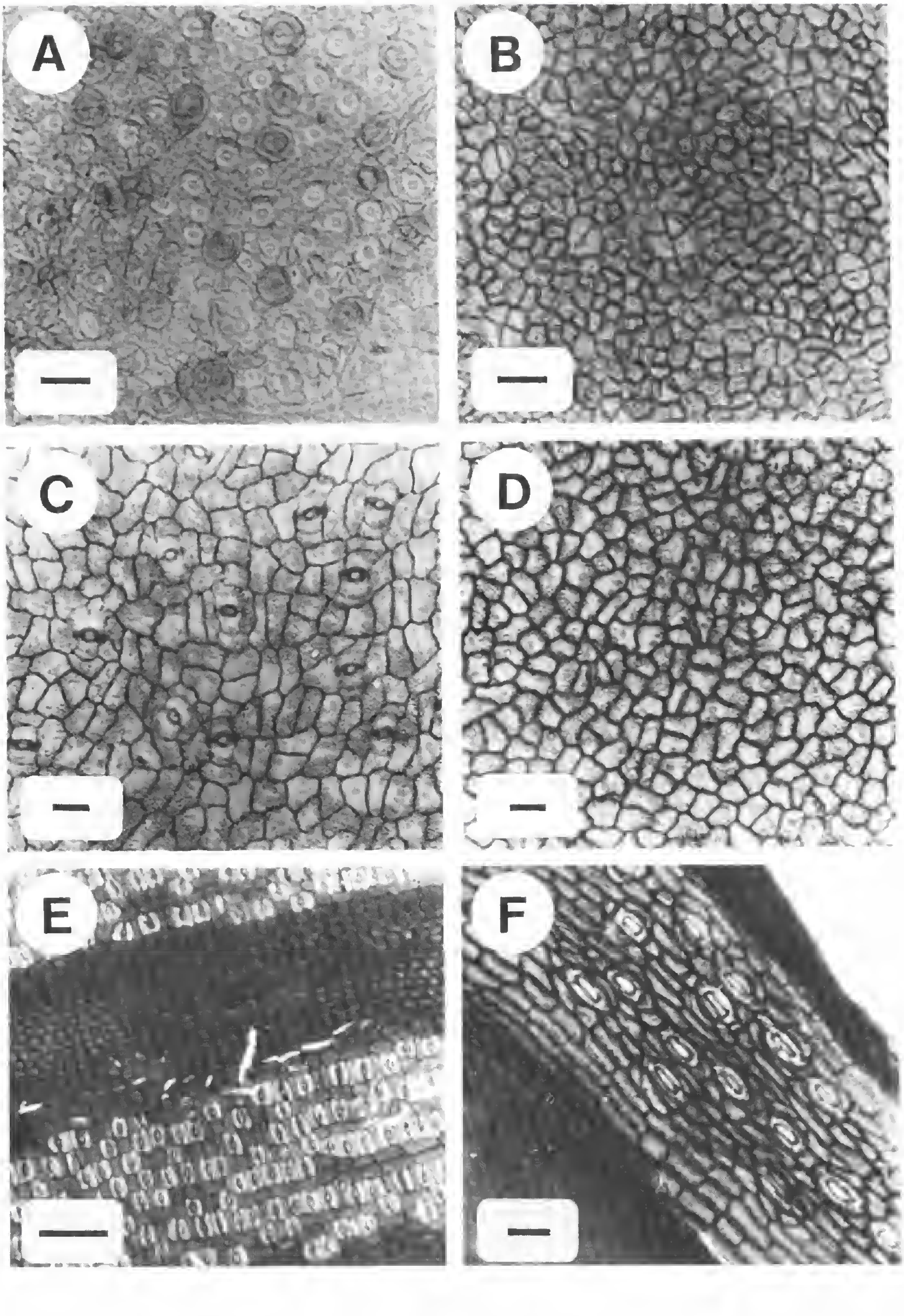
There are twelve other broadleafed parataxa. Parataxon 2 is a lobed, serrate leaf which, while quite large, is very brittle and has not been recovered as a complete leaf (Fig. 2B). It usually occurs as a pinnately lobed specimen with three apparent lobes. These lobes are toothed near their apex. Secondary venation is brochidodromous near the base of each lobe and semicraspedodromous near the apex when teeth are present. Cuticles prepared from these leaves show that the leaf is hypostomatic with numerous stomates on the abaxial surface possessing a paracytic subsidiary cell arrangement (Fig. 3C). This, coupled with the numerous four-celled trichome bases observed on both surfaces of the leaf (Fig. 3C, D), places the parataxon in the Proteaceae. While more detailed comparisons will be required for final identification, preliminary examination indicates a similarity in structure to several species of *Grevillea*.

The vein pattern of Parataxon 3 showing numerous, close spaced, high angle secondary veins forming a distinct intermarginal vein suggests that the parataxon belongs in the Myrtaceae (Fig. 1C). Examination of the cuticle confirms this with the presence of diagnostic lid or capping cells on both surfaces (Fig. 2E, F). This leaf type is one of the most variable in size and shape. However, Christophel & Lys (1986) demonstrated that such interspecific variation is common within the family. They also demonstrated that no obvious foliar character or suite of characters defined genera within the family, and that the capsular fruited taxa and berry fruited taxa often numerically clustered together (were morphologically similar). It is interesting to note that while the Nelly Creek Myrtaceae bear some general similarity to genera of both capsular (e.g. *Lophostemon*) and berry fruited (e.g. *Syzygium*) groups in the family, there is no close similarity to *Eucalyptus*. The Nelly Creek *Myrtaciphyllum* is formally described in the following section. Capsular fruits with likely Myrtaceae affinities have been recovered from a Nelly Creek macerate (Fig. 5C), and will be described when more material becomes available.

The remaining 10 parataxa are all relatively rare in those samples processed to date. All but four are represented by only one specimen. Some of these remaining parataxa are distinctive, and assignable to families, and in some cases genera, so are worth discussing in the overall floristic context of the paper. The first of these broadleafed taxa is assignable to *Agathis* (Araucariaceae) based on general form and cuticular structure (e.g. Hill & Bigwood 1987; Stockey & Ko 1986).

A comparison of all the leaves examined (220 broadleafed and 49 microphyllous) can be seen in Table 1. Parataxon 5 (one specimen) can be placed in the Lauraceae based on the size and nature of the stomatal ledges and also the subsidiary cells (Fig. 4C, D) (Hill 1986). Parataxon 6 (one specimen) can be assigned to *Brachychiton* (Sterculiaceae) based on the hair bases and stomatal arrangement. Because the specimen is fragmentary (one lobe) very little can be said as to its specific affinities. Interestingly, three of the other parataxa (two non-entire and one entire margin) can be placed in the Proteaceae. A final parataxon (Parataxon 8) is represented by three specimens and is clearly a monocotyledon based on the parallel venation and the stomatal type.

Fig. 3. Cuticles of leaves illustrated in Fig. 2. A = abaxial cuticle of NC1000 (Parataxon 1); B = adaxial cuticle of NC1000; C = abaxial cuticle of NC1012 (Parataxon 2); D = adaxial cuticle of NC1012; E = abaxial cuticle of NC1017 (Holotype of *Myrtaciphyllum eremaeensis*); F = adaxial cuticle of NC1017. Insert for F is an enlarged view of a lid cell: Scale bars = 5 μm except the insert where bar = 2.5 μm.


A
B
C
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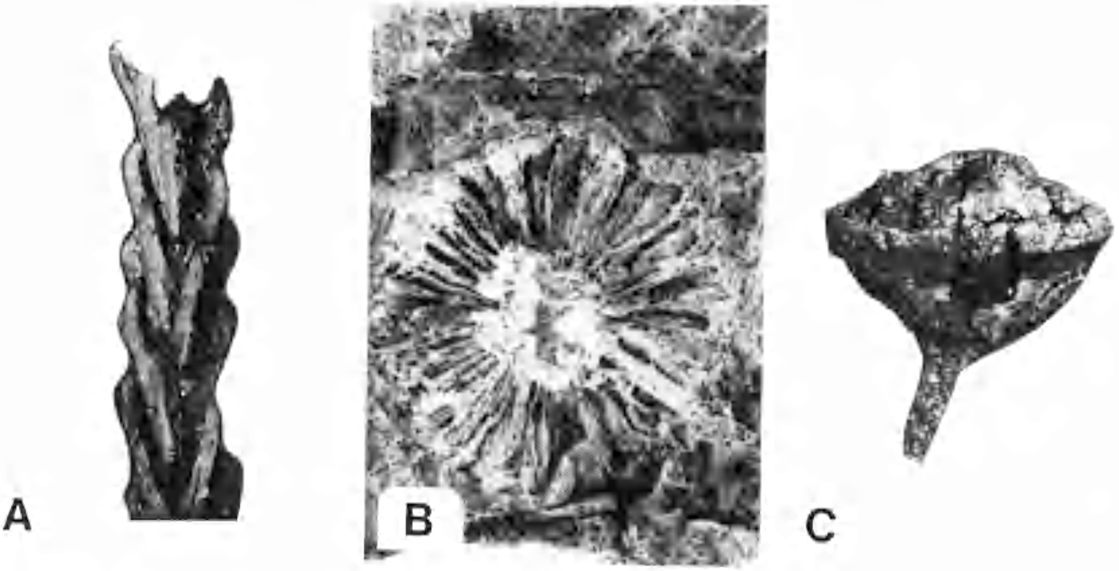

Fig. 5. Miscellaneous structures from the Nelly Creek and Poole Creek deposits; A = NC1501 – twig of Parataxon 14 (Podocarpaceae) from Nelly Creek X8; B = possible Proteaceae infructescence from Poole Creek Silcrete deposit X2; C = NC1500 – leptospermoid fruit (Myrtaceae) from Nelly Creek X10.

In addition to the 13 broadleafed parataxa, three microphyllous parataxa were collected. These include one conifer and two distinct species of *Gymnostoma* (Casuarinaceae). Based on macromorphological features, the conifer could be either Cupressaceae or Podocarpaceae (Fig. 5A). However, the cuticle clearly shows that this parataxon belongs to the Podocarpaceae (Fig. 4F).

Approximately 20 twigs were recovered which were assignable to *Gymnostoma*. It has been shown that cuticle features are distinctive in extant species of this genus (Dilcher *et al.* 1990; Scriven & Christophel 1990), and examination of the Nelly Creek specimens revealed that two species were present. A cuticle of one of the two Nelly Creek types is shown in Fig. 4E. No fertile material has been recovered thus far.

Although the taxonomic study of the flora is preliminary, 12 of the 16 parataxa recognised can be assigned to some formal taxonomic level. This means that at least a very generalized comparison may be made with other floras and with modern vegetation types.

Taxonomic Description

Order: Myrtales
Family: Myrtaceae
Genus: *Myrtaciphyllum* Christophel & Lys, 1986

Myrtaciphyllum eremeaensis sp. nov.
FIGS 2C, 3E–F

Diagnosis

Architectural features: leaf shape elliptic, ovate or obovate. Size range: 3.5–13 cm long by 1.5–4 cm maximum width. Leaf tip acute or attenuate, rarely acuminate. Leaf base acute, rarely obtuse. Primary venation pinnate, secondary veins straight, brochidodromous with a prominent intermarginal vein.

Cuticular features: leaves hypostomatic, stomatal complex anomocytic, with between three and six subsidiary cells (three or four most common). Anticlinal epidermal cell walls angular – straight to slightly curved. Cells of both upper and lower epidermis equal sized; no striations visible on periclinal walls. Simple hairs infrequent (less than three per mm^2) on both surfaces. Hydathodes rare on lower

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Fig. 4. Miscellaneous cuticles from Nelly Creek parataxa. A = abaxial cuticle of NC1003 (Parataxon 7 – Proteaceae); B = adaxial cuticle of NC1003; C = abaxial cuticle of NC1011 (Parataxon 5 – Lauraceae); D = adaxial cuticle of NC1011; E = cuticle of NC1301 (*Gymnostoma* sp A – Parataxon 15); F = cuticle of NC1302 (Podocarpaceae – Parataxon 14); Scale bars = 5 μm.

(abaxial) epidermal surface, apparently absent on adaxial (upper) surface. Lid cells numerous on both surfaces with S-shaped to straight sinus showing no beaded thickening or perforations (Fig. 3F-inset). Epidermal cells surrounding lid cells frequently modified into a somewhat radial pattern – particularly on upper epidermis.

Holotype: Specimen NC 1017, housed in the Palaeobotany Collection, Botany Department, Adelaide University, as one mummified leaf and one cuticle slide (NC–C 1017)

Type Locality: Nelly Creek, S.A. (29°19′S, 137°18′E)

Collector: D. C. Christophel

Etymology: from Eremean, referring to the large, central Australian arid vegetation province used by L. A. S. Johnson and B. Briggs as a distributional region for Australian Myrtaceae and Proteaceae (e.g. Johnson & Briggs 1981). The type locality occurs within this region.

Description of Holotype: Collected in 1988. Leaf 51 mm long by 22 mm wide at position of maximum width. Elliptic, symmetrical with attenuate apex (apex angle 35°) and acute base (57°). Secondary veins are straight, average angle 37°.

Cuticle typical for the species. Stomates located on abaxial surface with three to six subsidiary cells. Average length of stomates 20 μm (mean L/W = 1.0). Anticlinal epidermal cell walls angular – straight to slightly curved with no thickening or beading. Cells of both abaxial and adaxial cuticles equal size (mean 20 × 20 μm – range 15–30 μm). No striations visible on periclinal walls. Simple hairs rare on both surfaces. Large multicellular hair bases present, and no hydathodes visible on sample prepared from holotype.

Lid cells numerous on both surfaces with S-shaped to straight sinuses, showing no beaded thickening or perforations. Epidermal cells surrounding lid cells frequently modified into radial pattern. Lid cell size = 20 × 20 μm. Density of lid cells 12 per 100 × 100 μm section.

Comparison with other species: The first two species described for the genus could not be distinguished by leaf architectural features, and cuticular characters were used (Christophel & Lys 1986). The same situation applies to *Myrtaciphyllum eremeaensis*, as the specimens included overlap both previously described species in macromorphological and venation features. In cuticular features, however, *M. eremeaensis* is distinct from *M. undulatum* from the Eocene of Anglesea in that it lacks the sinuous anticlinal walls of the epidermal cells exhibited by the latter species. *M. eremensis* differs from *M. douglasii* from Anglesea in having numerous lid cells on both surfaces as compared to a complete lack of lid-cells in the latter species.

Physiognomic Interpretation

Christophel & Greenwood (1989), in discussing litter deposition in Australian rainforests, demonstrated that there was a predictable physiognomic signature for the forest types categorized by Webb (1959). Of the 220 broadleafed specimens recovered from Nelly Creek samples, it is possible to measure (or estimate) the length and maximum width for approximately 160. Results showed that there were no mesophylls present, while approximately 20% of the leaves (40% of taxa) were notophylls and 80% of the leaves (60% of the taxa) were microphylls. The discrepancy between species and total leaves reflects the high frequency of one microphyll parataxon and the attendant rarity of most other parataxa. This single parataxon domination was reflected to a lesser degree in the margin type percentage, with 88% of leaves (75% taxa) entire-margined. If Nelly Creek leaf length, maximum width and position of maximum width are superimposed on the box diagram of physiognomic signatures from Christophel & Greenwood (1988, Fig. 3) it becomes apparent that the Nelly Creek flora does not resemble Golden Grove or Anglesea, having much smaller leaves than either of them. Even remembering the caveat concerning interpretation of small sample numbers, there are several interesting subjective observations that can be coupled with the above physiognomic data. Unlike the other Middle Eocene deposits mentioned earlier, there is no evidence of drip tips in the Nelly Creek flora. Additionally, very few germlings (*sensu* Lange 1976) are present on leaf cuticles, and in general the leaves from Nelly Creek can be considered more sclerophyllous. This includes such features as generally thicker cuticles, denser trichomes, and smaller, more coriaceous or woody leaves. These features would tend to suggest a drier (or certainly more seasonally dry) climate than the other reported Eocene megafossil deposits, or alternatively a much more depauperate soil nutrient level (Beadle 1963).

Comparison with other Eocene Floras

The first impression of the Nelly Creek flora with its total of 16 parataxa is one of clear dominance and low diversity. However, some of this can be most likely attributed to the small sample size and limited portion of the clay lens sampled. For the better known Australian Eocene floras, the diversity is higher. For example, the most thoroughly studied clay lens at Anglesea has over 40 parataxa (Christophel *et al.* 1987), Golden Grove has over 30 parataxa (Barrett & Christophel 1990) and Maslin Bay is estimated at approximately 200 parataxa (Christophel & Blackburn 1976) or perhaps as low as 150 (L. J. Scriven unpubl. data).

TABLE 2. *Leaf litter composition of two one metre square quadrats at Noah Creek.*

Species Present	Quadrat One Leaf Numbers # (%)	Quadrat Two Leaf Numbers # (%)
Ceratopetalum macropetalum	68 (33.5)	58 (29)
Acacia aulacocarpa	29 (14)	23 (11)
Buckinghamia ferruginiflora	21 (10)	30 (15)
Lindsayomyrtus brachyandrus	18 (9)	22 (11)
Medicosma sessiliflora	12 (6)	10 (5)
Choriceras majus	12 (6)	14 (7)
Beilschmiedia oligandra	8 (4)	5 (2.5)
cf. *Diospyros hebecarpa*	8 (4)	7 (3.5)
Dissiliaria laxinervis	6 (3)	7 (3.5)
Euodia hortensis	5 (2)	8 (4)
Xanthostemon chrysanthus	3 (1.5)	0
Franciscodendron laurifolium	3 (1.5)	4 (2)
Orites sp. nov.	2 (1)	1 (0.5)
Syzygium kuranda	2 (1)	1 (0.5)
Sarcopteryx aff. *martyana*	2 (1)	3 (1.5)
Calophyllum australianum	1 (0.5)	0
Syzygium erythrocalyx	1 (0.5)	0
Unknown A	2 (1)	0
Unknown B	1 (0.5)	0
Unknown C	0	4 (2)
Unknown D	0	2 (1)
Unknown E	0	1 (0.5)
Unknown F	0	1 (0.5)
TOTAL TAXA	19	18
TOTAL LEAVES	204 (100)	202 (100)

It is possible to test the relationship between sample size and diversity in both fossil deposits and extant rainforests where the diversity is known. When four random samples of 250 leaves each were taken from the Anglesea lens mentioned above, the mean diversity was 18 ±3 (D. Christophel unpubl. data). Similarly, recent collections from an extant *Gymnostoma* community on a half hectare island in Noah Creek in the Daintree region of north Queensland showed that, although 75 different tree species occurred on the island, two litter samples (containing 200–300 leaves) had a diversity of less than 20 species per sample (Table 2). Therefore, the 16 preliminary parataxa recovered at Nelly Creek could easily represent less than half of the expected total diversity for the fossil flora, and an even smaller fraction of the diversity of the forest from which it was derived.

A more accurate estimation of the diversity of a flora may be had from a study of its dispersed cuticle (Rowett & Christophel 1990). Samples of clay from Nelly Creek had an average diversity of 26 cuticle parataxa, while similar sized samples from Golden Grove yielded 25–32 parataxa (A. Rowett pers. comm.). Rowett reported that the samples were dominated by fragments of Myrtaceae leaves – probably all belonging to *Myrtaciphyllum eremaensis*.

At higher taxonomic levels, the flora has many elements common to other Middle Eocene floras. Golden Grove, Anglesea and Nelly Creek contain abundant (greater than 10%) Myrtaceae leaves. Similarly, Anglesea has approximately the same percentage of the flora made up of Proteaceae species as does Nelly Creek. *Gymnostoma* is found at Nelly Creek, Anglesea, Nerriga and Maslin Bay. *Brachychiton* is known from all of the Eocene localities except Nerriga, and *Agathis* is found at Maslin Bay and Nelly Creek. One interesting floristic difference, however, is in the representation of the Lauraceae. At Maslin Bay, Nerriga, Anglesea and Golden Grove this family is both plentiful and diverse, while at Nelly Creek only one leaf has been recovered. Similarly, the Elaeocarpaceae (aff. *Sloanea*/*Elaeocarpus*), which is well represented at Anglesea, Golden Grove and Maslin Bay, has not been recovered at Nelly Creek.

At the specific level, the differences are more pronounced. The entire margined microphyll (Parataxon 1) at Nelly Creek is not known from any other locality. Parataxon 2 (lobed Proteaceae) is also absent from all other floras. The two Nelly Creek *Gymnostoma* species are taxonomically distinct from the common species at Anglesea. The Podocarpaceae parataxon at Nelly Creek is different to any reported from the other localities. Comparisons of the *Brachychiton* and *Agathis* species have yet to be made. The Nelly Creek *Myrtaciphyllum* species is definitely different from either species at Anglesea.

While a brief comparison of the foliar physiognomy was made in the preceding section, the generalization can be made that the floristic elements at Anglesea, Golden Grove and Maslin Bay all show more tropical and/or high moisture regime features. These three Middle Eocene deposits all have leaves with drip tips, prolific, high rank germlings, and noticeable quantities of leaves in Webb's (1959) mesophyll size class, in direct contrast to Nelly Creek. Although certain Gondwanic families are shared between Nelly Creek and the other Middle Eocene deposits (e.g. Myrtaceae, Proteaceae, Casuarinaceae, Podocarpaceae), the specific floristic composition and the physiognomic signature is different for Nelly Creek.

Comparison with Silcrete Floras

Early studies of the silcrete deposits of northern South Australia concentrated on the description and evolutionary importance of some of the plants (Chapman 1937; Lange 1978, 1982; Ambrose *et al.* 1979). More recent studies have attempted to address the important aspects of the stratigraphy of the deposits and of their comparative floristics (Greenwood *et al.* 1990). A major problem with these silcrete floras has been the lack of stratigraphic continuity with data strata, and thus the age has been difficult to determine. This has been highlighted by Ambrose *et al.* (1979), where a possible Miocene age is suggested early in the paper and later in the same paper an Eocene age is supported. In their recent studies, Greenwood *et al.* (1990) found that there were two distinct macrofossil floras in the Poole Creek silcrete locality, and based on their taxonomic composition and on the stratigraphy of near-by sedimentary units they determined that one flora was restricted to the upper Eyre Formation (Middle Eocene) and the other to the Etadunna Formation (Oligo-Miocene) sediments. Comparison between the Eyre Formation silcrete flora (Eocene) and the Nelly Creek fossils of palynologically determined Middle Eocene age therefore becomes important.

Preliminary comparisons do not result in the definite conclusion that the Eyre Formation silcretes and the Nelly Creek flora represent the same vegetation. However, some common taxa are present and the comparison most certainly needs to be made more rigourously when additional Nelly Creek material is available. In support of the correlation, *Gymnostoma* is common in the silcrete and at Nelly Creek. However, it commonly occurs as female infructescences in the former and only as vegetative remains in the latter. Until reproductive material is recovered from Nelly Creek, conspecificity cannot be determined. Similarly, a lobed Proteaceae leaf very similar to Nelly Creek Parataxon 2 commonly occurs in the silcretes. Two other parataxa from Nelly Creek, a narrow linear, entire-margined Proteaceae leaf and *Brachychiton* also occur in the silcrete. Again, further studies are required to determine conspecificity — particularly as the Nelly Creek *Brachychiton* is only a single lobe, and hence even a rudimentary character, like the number of lobes present, cannot be compared.

Within the silcretes there also commonly occurs a flattened, woody reproductive structure (Fig. 5B). Based on silcrete impressions alone, the structure has not been identifiable, and has not been recorded from any other published fossil plant locality known to the authors. However, one specimen of this structure has now been recovered from a Nelly Creek macerate. Although the specimen has fragmented, it can be seen that each of the woody wedges consists of two flattened, appressed woody bracts. More detailed study is still required, but it would appear that the structure has some similarity to a Proteaceae cone — e.g. like the flattened infructescence of *Isopogon* or *Dryandra*. In the original paper describing silcrete material, Chapman (1937) figured a specimen and labelled it as a "*Banksia* flowering tip." That specimen, however, does not resemble those discussed here.

Some credence is given to the interpretation of the woody reproductive structures as Banksiae Tribe (Proteaceae) infructescences by the fact that the silcrete floras contain serrate foliage identified by Greenwood *et al.* (1990) as *Banksiaeformis* Hill & Christophel, which could have affinities with *Dryandra*. Unfortunately, no such *Banksiaeformis* leaves have been recovered at Nelly Creek.

Other evidence does not support the correlation. In addition to the common *Banksiaeformis* leaves in the silcretes, other toothed leaves with possible affinities to either the Cunoniaceae or Elaeocarpaceae are reported from there (Greenwood *et al.* 1990) and are missing from Nelly Creek. Of particular interest, the narrow, sometimes falcate Myrtaceae leaves which bear similarity to *Eucalyptus*, while common in the silcretes, are also absent from Nelly Creek. Finally, the dominant, brochidodromous Parataxon 1 from Nelly Creek has not been reported in the silcrete deposits (Greenwood *et al.* 1990).

Physiognomically, the silcretes contain larger leaves than Nelly Creek has thus far yielded, and also a higher percentage of non-entire margined leaves. It is reported (N. F. Alley pers. comm.) that blocks of clay with large leaves peeling off them were unearthed on an early expedition to the locality. Unfortunately these blocks did not survive transport to Adelaide, and our more recent material has not contained such leaves. However, this serves to illustrate the potentially mosaic distribution of taxa within the clay, and also highlights the need for additional collections. It is certainly the case, however, that some of the sclerophyllous nature of the Nelly Creek leaves is mirrored in the portion of the Poole Creek silcrete flora considered by Greenwood *et al.* (1990) to be Middle Eocene.

Discussion

The potential of the Nelly Creek flora to add to our broader knowledge of Middle Eocene Australia floras has been mentioned in the introduction. Examination of that flora more closely has emphasized this importance. Firstly, the preliminary taxonomic assessment has shown that the flora has a very different composition to that of the other well known Australian Middle Eocene macrofossil floras. While some of the major Gondwanic families, including the Proteaceae, Myrtaceae, Casuarinaceae, Podocarpaceae and Araucariaceae are present in all floras of that age, the generic and specific composition of the floras is different. Physiognomically, the Nelly Creek flora is different from the Golden Grove, Anglesea, Maslin Bay and Nerriga floras, being decidedly smaller leafed and lacking the numerous rainforest indicators (driptips etc.) shown by those floras. The inland position of the locality is perhaps responsible for the difference in floristics and physiognomy seen at Nelly Creek, and our overview of Middle Eocene Australia must be tempered accordingly.

The potential importance of the Nelly Creek locality to our understanding of South Australia's silcrete floras must also be emphasized. While the evidence for positive correlation is poor, the presence of certain indicator taxa, such as the disk-shaped woody reproductive structure and the narrow lobed Proteaceae leaf in both deposits and in no others, must certainly be taken as encouragement for further collections and comparisons.

Greenwood *et al.* (1990) suggested that the assumed Eocene elements of the silcrete floras might well represent deciduous seasonal vegetation types mixed with a wetter riparian element such as those associated with monsoonal vine thickets in Queensland today. Such an interpretation for the Nelly Creek locality is consistent with both the known elements of the flora and also the physiognomic interpretation, and a more thorough search of modern forest types of this description will be made in the hope of identifying further elements in the Nelly Creek flora — particularly the dominant parataxon.

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